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Verification of the Translation

I, Kazuo Ueda, being conversant in both of the Japanese and the English languages, do hereby verify that the attached is a true English language translation of the specification of Japanese Patent Application No. 2003-147107, filed on May 26, 2003.

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Signature: Kazuo Ueda

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[Title of the Invention]

Micro power converter with plural outputs

[Claims]

1. A micro power converter with plural outputs comprising:

a semiconductor substrate having semiconductor integrated circuit(s);

a plurality of thin film magnetic induction components each formed on a magnetic insulative substrate;

a magnetically isolating layer that magnetically isolates the thin film magnetic induction components from each other; and

a capacitor(s).

2. A micro power converter with plural outputs comprising:

a semiconductor substrate having semiconductor integrated circuit(s);

a plurality of thin film magnetic induction components each of which comprises a magnetic insulative substrate, a coil conductor formed on the magnetic insulative substrate, and a plurality of

connection terminals formed in a peripheral portion of the magnetic insulative substrate; and

a capacitor(s);

wherein the plurality of thin film magnetic induction components are laminated with a gap between the adjacent thin film magnetic induction components that are fixed with the connection terminals.

3. The micro power converter with plural outputs according to claim 1 or claim 2, wherein the magnetic insulative substrate is a ferrite substrate.

4. The micro power converter with plural outputs according to claim 1, wherein the thin film magnetic induction components are magnetically isolated with each other by a nonmagnetic material.

5. The micro power converter with plural outputs according to claim 4, wherein the nonmagnetic material is a resin material.

6. The micro power converter with plural outputs according to claim 4, wherein the nonmagnetic material is a ceramic material.

7. The micro power converter with plural outputs according to claim 2, wherein

the connection terminals in one of the magnetic insulative

substrates are formed at same planar positions as positions of the connection terminals in other magnetic insulative substrates;

a planar position of one of the connection terminals connecting to either end of the coil conductor is different from a planar position of corresponding connection terminal connecting to either end of a coil conductor in adjacent thin film magnetic induction component; and

height of the connection terminals formed in at least one of the two adjacent magnetically insulative substrates is higher than height of the coil conductor formed on the at least one magnetically insulative substrate.

8. The micro power converter with plural outputs according to any one of claims 1 through 7 comprising a pair or pairs of the connection terminals, one terminal of the pair of connection terminals being formed on a first principal surface of the magnetic insulative substrate, the other terminal of the pair of connection terminals being formed on a second principal surface of the magnetic insulative substrate, and the terminals of the pair of terminals being electrically connected through a through hole formed in the magnetic insulative substrate.

9. The micro power converter with plural outputs according to claim 8, wherein some of the connection terminals electrically connect to the semiconductor substrate.

10 The micro power converter with plural outputs according to claim 8 or claim 9, wherein some of the connection terminals electrically connect to the capacitor.

[Detailed Description of the Invention]

[0001]

[Technical field of the invention]

The present invention relates a micro power converter, such as a DC-DC converter, for plural outputs. The micro power converter comprises a semiconductor integrated circuit (hereinafter abbreviated to IC) formed on a semiconductor substrate and passive components including coils, capacitors, and resistors.

[0002]

[Background of the invention]

Electronic information apparatuses, particularly a variety of portable electronic information apparatuses have been remarkably popularized in recent years. Many of the electronic information apparatuses have a battery as a power source and are equipped with a power converter such as DC-DC converter. The power converter generally has a structure of a hybrid type module comprising discrete parts of active components and passive components arranged on a printed circuit board of ceramics or plastics. The active components include switching devices, rectifying devices and controller ICs; the

passive components include coils, transformers, capacitors and resistors.

Fig. 32 shows a circuit diagram of a DC-DC converter. Inside of the peripheral dotted line 50 represents a DC-DC converter circuit.

[0003]

The DC-DC converter comprises an input capacitor Ci, an output capacitor Co, a regulator resistor RT, a capacitor CT, an inductor L, and a power supply IC. DC voltage Vi is input; MOSFETs of the power supply IC switch on and off; and specified DC output voltage Vo is output. The inductor L and the output capacitor Co are parts of a filter circuit for output of a DC voltage.

If the DC resistance of the inductor L in the circuit increases, voltage drop in the part increases resulting in decrease of the output voltage, Vo, which means decrease of conversion efficiency of the DC-DC converter. Miniaturization of the portable and other variety of electronic information apparatuses strongly needs miniaturization of a power converter installed in the apparatus. Miniaturization of hybrid type power supply modules has been progressing by means of MCM (multiple-chip module) technique and laminated ceramics parts technique. However, packaging of discrete parts arranged on one substrate restricts reduction of a package area of the power supply module. Magnetic induction components such as inductors and transformers, in particular, which occupy much larger volume than ICs, impose most severe restraint on miniaturization of electronic

apparatuses.

[0004]

Miniaturization of the magnetic induction components could be sought along two directions; a direction in which the total size of the power supply is reduced by planar packaging of chip parts miniaturized to an extreme limit, and another direction in which thin film parts are formed on a silicon substrate. Some examples have been disclosed recently in which thin micro magnetic components, for example coils and transformers, are mounted on a semiconductor substrate applying semiconductor technology, in response to demand for minimizing magnetic induction components. The inventors also devised such a planar type thin film magnetic induction component. (See Patent document 1).

This is a planar magnetic induction component (a thin film inductor) comprising a thin film coil sandwiched by a magnetic thin film and a ferrite substrate formed by a thin film technology on a surface of a semiconductor substrate incorporating semiconductor components such as switching elements and controller circuits. A thin film type magnetic induction component and reduction of packaging area were achieved by this device. Problems, however, remain in that many discrete chip parts still exist and packaging area is large yet.

[0005]

To solve the problems, the inventors further devised a micro

power converter that has already been disclosed. (See Patent document 2). A planar magnetic induction component installed in this micro power converter is formed by filling a gap of a spiral-shaped coil conductor with resin containing magnetic fine particles and sandwiching the coil conductor with ferrite substrates.

The inventors also devised a micro power converter exhibiting high efficiency by combining a power supply IC and an inductor formed with a solenoid-shaped coil. The micro power converter is described in Japanese Patent Application No. 2003-008714.

[0006]

[Patent document 1]

Japanese Unexamined Patent Application Publication No. 2001-196542

[Patent document 2]

Japanese Unexamined Patent Application Publication No. 2002-233140

[0007]

[Problem to be solved by the invention]

The micro power converter proposed by the inventors and described above, though small and thin, has only one magnetic inductor component and one IC, and directs to a single output system with one input and one output. Consequently, a plurality of the micro power converters is required to obtain a plurality of outputs.

Many of portable and other electronic apparatuses that demand a

micro power converter need a plurality of outputs, that is, need a plurality of output voltages. Therefore, a plurality of the micro power converters is necessary and the packaging area for the converters is large, resulting in an increased packaging cost.

[0008]

Therefore, an object of the present invention is to solve the above problems and to provide a micro power converter with plural outputs, the converter supplying a plurality of output voltages, being small and thin, occupying small packaging area, and having a plurality of output systems.

[0009]

[Means to solve the problems]

To attain the above object, a micro power converter with plural outputs according to the present invention contains the following features.

(1) A micro power converter with plural outputs of the invention comprises a semiconductor substrate having semiconductor integrated circuit(s), a plurality of thin film magnetic induction components each formed on a magnetic insulative substrate, a magnetically isolating layer that magnetically isolates the thin film magnetic induction components from each other, and a capacitor(s).

(2) A micro power converter with plural outputs of the invention comprises a semiconductor substrate having semiconductor integrated circuit(s), a plurality of thin film magnetic induction

components each of which comprises a magnetic insulative substrate, a coil conductor formed on the magnetic insulative substrate, and a plurality of connection terminals formed in a peripheral portion of the magnetic insulative substrate, and a capacitor(s), wherein the plurality of thin film magnetic induction components are laminated with a gap between the adjacent thin film magnetic induction components that are fixed with the connection terminals.

(3) In the micro power converter with plural outputs of (1) or (2), the magnetic insulative substrate is advantageously a ferrite substrate.

(4) In the micro power converter with plural outputs of (1), the thin film magnetic induction components are advantageously magnetically isolated with each other by a nonmagnetic material.

(5) In the micro power converter with plural outputs of (4), the nonmagnetic material is advantageously a resin material.

(6) In the micro power converter with plural outputs of (5), the nonmagnetic material is advantageously a ceramic material.

(7) In the micro power converter with plural outputs of (2), the connection terminals in one of the magnetic insulative substrates are formed at same planar positions as positions of the connection terminals in other magnetic insulative substrates, a planar position of one of the connection terminals connecting to either end of the coil conductor is different from a planar position of corresponding connection terminal connecting to either end of a coil conductor in adjacent thin film magnetic induction component, and height of the

connection terminals formed in at least one of the two adjacent magnetically insulative substrates is higher than height of the coil conductor formed on the at least one magnetically insulative substrate.

(8) In the micro power converter with plural outputs of any one of (1) through (7) that comprises a pair (or pairs) of the connection terminals, one terminal of the pair of connection terminals is formed on a first principal surface of the magnetic insulative substrate, the other terminal of the pair of connection terminals is formed on a second principal surface of the magnetic insulative substrate, and the terminals of the pair of terminals are electrically connected through a through hole formed in the magnetic insulative substrate.

(9) In the micro power converter with plural outputs of (8), advantageously some of the connection terminals electrically connect to the semiconductor substrate.

(10) In the micro power converter with plural outputs of (8) or (9), advantageously some of the connection terminals electrically connect to the capacitor.

[0010]

[Aspects of embodiment of the invention]

[Example 1]

Fig. 1 and Fig. 2 show an essential structure of a micro power converter with plural outputs of a first example of embodiment according to the present invention. Fig. 1 is a top plan view of an

inductor that is a thin film magnetic induction component. Fig. 2(a) is a cross sectional view along the line X-X of Fig. 1. Fig. 2(b) is a cross sectional view along the line Y-Y of Fig. 1. There are two inductors in this example. These figures contain not only coil patterns of the inductors but also connection terminals 15a and 15b that are packaging terminals of the inductors for electrical connection.

[0011]

In Fig. 1, coil conductors 12a and 13a are formed on the first principal surface of magnetic insulative substrates 11 and coil conductors 12b and 13b are formed on the second principal surface of the substrates. The coil conductors 12b and 13b formed on the second principal surface have a straight linear form in a plan view. The coil conductors 12b and 13b electrically connect to the coil conductors 12a and 13a on the first principal surface through connecting conductors 14 formed in through holes. Each of the coil conductors 12a and 13a on the first principal surface, connecting to an adjacent coil conductor of the coil conductors 12b and 13b on the second principal surface through the connecting conductor 14, is formed slightly oblique with respect to the coil conductors 12b and 13b. (The figure is drawn in exaggeration.) The coil conductor 12a, the coil conductor 12b, and the connecting conductor 14 form a solenoid coil, and the coil conductor 13a, the coil conductor 13b, and the connecting conductor 14 form another solenoid coil.

[0012]

A magnetically isolating layer 17 is formed of a nonmagnetic material between the magnetic insulative substrates 11. The magnetically isolating layer 17 magnetically isolates an inductor 1 that is a thin film magnetic inductive component composed of the magnetic insulative substrate 11, the coil conductors 12a and 12b, and the connecting conductor 14 from an inductor 2 that is another thin film magnetic inductive component composed of the magnetic insulative substrate 11, the coil conductors 13a and 13b, and the connecting conductor 14. "Magnetically isolated" here, means that induced voltage is not mutually generated when electric current flows in the inductor 1 or inductor 2 in operation as a power supply. That means the mutual inductance is low enough not to affect operation of the power supply.

[0013]

Fig. 3 is a cross sectional view of a principal part of the first example of a micro power converter with plural outputs. A semiconductor substrate 22 installing a power supply integrated circuit (IC) is disposed over one surface, upper surface here, of the magnetic insulative substrates 11. Inductors and power supply IC, which are two types of major components of a power converter, are integrated and miniaturized in the whole. The power supply IC is designed to have two output systems. Since two inductors are also formed, the power converter provides two outputs. Stud bumps 21 are formed on electrodes of the power supply IC formed on the

semiconductor substrate 22. The semiconductor substrate 22 and the connection terminals 15a formed on the magnetic insulative substrate 11 are ultrasonically bonded through the stud bumps 21. Underfil 23 can be provided for sealing as necessary.

[0014]

A capacitor is omitted in Fig. 3. Although discrete capacitors may be provided, a capacitor component of laminated ceramic capacitor array can be connected to the connection terminal 15b formed on the other side of the magnetic insulative substrate 11 for further miniaturization.

The connection terminals 15a and 15b are electrically connected through a connecting conductor 16. The coil conductors 12a, 12b, 13a, and 13b are covered with a protective film 18 of an insulative resin material, though not shown in the plan view of Fig. 1.

The Figs. 4 through 13 show a method for manufacturing the first example of embodiment of a micro power converter with plural outputs and are cross sectional views illustrating essential steps in sequence of the manufacturing processes. The figures illustrate a manufacturing method for inductors, and the cross sections are similar to the cross section along Y-Y in Fig. 1.

[0015]

A magnetic insulative substrate used was a ferrite substrate 11 of Ni-Zn having a thickness of 525 μm. A thickness of the magnetic insulative substrate is determined depending on necessary

inductance, coil current, and properties of the magnetic substrate, and is not limited to the value of this example. However, if the magnetic insulative substrate is extremely thin, magnetic saturation tends to occur; if the substrate is too thick, the power converter itself becomes thick. Accordingly, the thickness needs to be determined matching to purpose of the power converter. Though a magnetic insulative substrate of ferrite was used in the example, other any appropriate insulative and magnetic substrate can also be used. A ferrite substrate was used here for ease of shaping to a substrate form.

[0016]

First, a ferrite substrate 11 is cut for forming a magnetically isolating layer in the ferrite substrate as shown in Fig. 4. The cutting can be conducted using any method selected from laser beam machining, sand blasting, electric discharge machining, ultrasonic machining, and dicing. Dicing was employed in this example to cut the magnetic insulative substrate into two halves. The magnetic insulative substrate was fixed with a tape 10 in advance to prevent the cut portions of the magnetic insulative substrate from being apart from each other. Thickness of the blade of dicing was 60 μm and the gap 41 of the cut was 70 μm.

Material of the tape 10 can be a thermally peeling tape that decrease adhesivity by heat or an ultraviolet radiation peeling tape that decrease adhesivity by irradiation of ultraviolet radiation. Any

tape can be used as far as it holds adhesivity at dicing and is easily peeled off in a later step. An ultraviolet radiation peeling tape was used in this example.

[0017]

The gap of cut was filled with liquid resin and thermally cured to form a magnetically isolating layer 17 of nonmagnetic material, which bonds the two magnetic insulative substrates, as shown in Fig. 5. Filling of the cut gap with resin was performed by repeating several times the steps in which liquid resin was placed at the cut gap by means of screen printing and the liquid resin was cured. The resulted surface was polished so that a step between the surface of the ferrite substrate and the resin surface is eliminated.

Through holes 42 and 43 were then formed as shown in Fig. 6 for connecting coil conductors 12a, 13a, and connection terminals 15a in the first principal surface, and corresponding member of coil conductors 12b, 13b, to the connection terminals 15b in the second principal surface. The coil conductors are connected through the through hole 42, and the connection terminals are connected through the through hole 43. Machining of the through holes 42 and 43 can be conducted by any method among laser beam machining, sand blasting, electric discharge machining, ultrasonic machining, and drilling. A method is to be selected taking machining cost and machining dimensions into consideration. The sand blasting method was employed in this example since the minimum width of the

machining dimension was a small value of 130 μm and a large number of places were to be machined.

[0018]

A seed layer of Ti/Cu for plating 44 was deposited by sputtering on the whole surface of the magnetic insulative substrate as shown in Fig. 7 as a pretreatment for forming connecting conductors 14 and 16 in the through holes 42 and 43, coil conductors 12a, 12b, 13a and 13b on the first and second principal surfaces, and connection terminals 15a and 15b. The seed layers 44 for plating are also formed on the surface of the through holes 42 and 43. The seed layer for plating 44 can alternatively formed by electroless plating. The sputtering method can be replaced by vacuum deposition or CVD (chemical vapor deposition). The method is desired to provide sufficient adhesiveness with the ferrite substrate 1. The conductive material can be any appropriate material exhibiting electrical conductivity. Though titanium was used for the adhesive layer, other materials including Cr, W, Nb, and Ta can also be used. The copper works as a seed layer for electroplating in the next step. The copper can also be replaced by nickel or gold. The copper / titanium was selected in this example considering ease of machining in the later steps.

[0019]

Then, a pattern for forming coil conductors 12a, 12b, 13a, 13b and connection terminals 15a, 15b on the first and second principal surfaces is formed using photoresist 45 as shown in Fig. 8. The

pattern was formed with negative type, film type photoresist 45.

The opening portion of the resist pattern is electroplated with copper to form a copper pattern composing coil conductors 12a, 12b, 13a, 13b as shown in Fig. 9. The through holes 42 and 43 are simultaneously plated with copper forming the copper pattern composing connecting conductors 14 and 16. The coil conductors 12a, 13a on the first principal surface and the coil conductors 12b, 13b on the second principal surface are connected by the connecting conductors, to form a coil pattern having a solenoid shape. At this stage, the seed layer for plating 44 remains on the whole surface of the ferrite substrate 11.

[0020]

After the electroplating, the photoresist 45 and unnecessary conductive layer (a seed layer 44 of copper / titanium) are removed as shown in Fig. 10. Thus, a coil conductor with solenoid shape comprising the coil conductors 12a, 12b, 13a, 13b and the connection terminals 15a, 15b is obtained.

The coil conductors 12a, 12b, 13a, 13b are covered with protective film 18 of an insulator film as shown in Fig. 11. A film type insulator material was used in this example. The protective film is not indispensable. But, the film is preferably formed considering long term reliability. The protective film is not limited to forming with film type material, and liquid insulator material can also be used to form a pattern by screen printing followed by thermal curing.

[0021]

Surfaces of the coil conductors 12a, 12b, 13a, 13b and the connection terminals 15a, 15b may be plated with nickel or gold to form a surface treatment layer, as necessary. In the process shown in Fig. 9 in this example, nickel and gold, not shown in the figure, were electroplated subsequently to electroplating of copper. The surface treatment layer may be formed after the step of Fig. 10 by electroless plating. Or the electroless plating may be conducted after the step of Fig. 11. The surface treatment layer of metallic protective conductor is helpful for holding stable condition in a later step of connecting the IC.

Then, a semiconductor substrate 22 installing a power supply IC is connected to the connection terminals 15a formed on the ferrite substrate 11 as shown in Fig. 12. In this example, stud bumps 21 are formed on an electrode, not shown in the figure, in the semiconductor substrate, and the stud bumps are fixed to the connection terminals 15a by ultrasonic bonding.

[0022]

The semiconductor substrate 22 is fastened to the inductors 1 and 2 with an underfil 23 as shown in Fig. 13. The semiconductor substrate 22 is fixed to the inductors 1 and 2 using the stud bumps 21 and ultrasonic bonding in this example. A method of the fixing is, however, not limited to this measure. Soldering or a method using a conductive adhesive can also be used. Nevertheless, resistance of

connection parts is favorably as small as possible.

The semiconductor substrate 22 was fastened to the inductors 1 and 2 with the underfil material in this example. The fastening, however, can be performed using any appropriate material, for example, a sealant of epoxy resin. The fastening member fastens each of the components (ICs and inductors) and is preferably provided for obtaining long term reliability, though does not affect initial performance of the power converter.

[0023]

By employing the above-described processes, a power converter packaging parts (a power supply IC and inductors) excepting a capacitor, can be miniaturized. The power converter having two output systems occupies smaller packaging area than two micro power converters having one output system each.

Specifically describing, a micro power converter with one output system has a size of 3.5 mm wide and 3.5 mm long. To obtain two outputs by that type of converter, a packaging area of at least 3.5 mm x 7.2 mm is required. A micro power converter with plural outputs having two output systems allows reducing number of electrodes of a power supply IC, since some electrodes can be shared by the two output systems. Thus, the packaging area is reduced to 3.5 mm wide and 5.8 mm long. A thickness is about 1 mm, which is equal to a thickness of a micro power converter having one output system. By virtue of reduction of packaging area and reduction of assembling

steps, which results from change to one micro power converter with plural outputs from two micro power converters, packaging costs can be reduced to a half.

[0024]

Further miniaturization can be achieved by bonding a laminated ceramic capacitor to the connection terminals of the inductor on the reverse side from the face that packages the IC.

[Example 2]

Fig. 14 shows a method for manufacturing a micro power converter with plural outputs of second example of embodiment of the present invention. Fig. 14(a) through Fig. 14(c) are cross sectional views of essential parts in sequence of manufacturing steps. The figures illustrate a process to fabricate ferrite substrate.

The second example of embodiment employs a ceramic material for magnetically isolating layer 17 in place of a resin in the first example of embodiment. As described previously for use of resin, a gap 41 of cut in the ferrite substrate 11 was formed after sintering step of the ferrite substrate and the gap was filled with resin. In the second example of embodiment, however, the ferrite and a ceramic are simultaneously sintered.

[0025]

A green sheet 51 is prepared before sintering the ferrite, as shown in Fig. 14(a).

A gap 52 of cutting and through holes 53, 54 are formed in the

green sheet 51 by punching as shown in Fig. 14(b).

The gap 52 is filled with ceramic paste 55 of alumina before sintering by a printing method as shown in Fig. 14(c). The ferrite and the ceramics in this disposition are sintered at the same time at 1,200°C. The sintering temperature, degree of thermal shrinkage due to sintering, and coefficient of thermal expansion of the ferrite and the ceramics are adjusted in this process so that cracks that would occur after the sintering are avoided and positional accuracy of the through holes is adjusted.

[0026]

Alumina was used for a ceramic material in this example. However, any material that allows adjusting thermal expansion rate and thermal shrinkage rate, and thermal expansion coefficient with respect to those of ferrite can be used including barium titanate, magnesium oxide, zinc oxide, and PZT (lead zirconate titanate).

Steps for forming coils after forming the ferrite substrate are similar to the steps shown in Figs 7 through 13. The method of this Example 2, as compared with Example 1, exhibits superior heat resistance and shows better results in long term reliability tests including pressure cooker tests and THB (temperature humidity bias) tests and in reliability tests including heat cycle tests and heat shock tests since the coefficient of thermal expansion of the materials is adjusted. The effects obtained in Example 1 can be, of course, attained in this Example 2.

[0027]

Number of integrated inductors can be increased corresponding to output systems, from the two inductors that were installed in Example 2. Such an example is shown in Fig. 15 in which four inductors are integrated. Increased number of inductors is to be designed considering output systems required by portable equipment mounting the power converter on the one hand and costs of packaging and the power converter on the other hand.

The coil pattern can also be varied from the solenoid in this example to a spiral shape or a toroidal shape. A magnetically isolating layer can be formed for those shapes and a micro power converter with plural outputs can be produced employing these shapes similarly to the case of the solenoid shape.

[Example 3]

Fig. 16 shows essential parts of a micro power converter with plural outputs of third example of embodiment according to the present invention. Fig. 16(a) is a plan view of first inductor and Fig. 16(b) is a plan view of second inductor. Each of these figures is a top plan view of an inductor that is a thin film magnetic induction component.

[0028]

Fig. 16(a) is a plan view of first inductor 60a, comprising first coil conductors 62a, 62b and first magnetic insulative substrate 61a (hereinafter referred to as first substrate 61a). Fig. 16(b) is a plan

view of second inductor 60b comprising second coil inductors 63a, 63b and second connection terminals 66a, 66b formed on second magnetic insulative substrate 61b (hereinafter referred to as second substrate 61b). The coil conductors 62a, 63a are formed on first principal surfaces and the coil conductors 62b 63b are formed on second principal surfaces. The connection terminals 65a, 66a are formed on the first principal surfaces and the connection terminals 65b, 66b are formed on the second principal surfaces.

The first connection terminal 65b connecting to the first coil conductor 62b is disposed at a planar position different from the position of the second connection terminal 66b connecting to the second conductor 63b so that the two inductors can be operated independently of each other to obtain two outputs. The first connection terminal 65a connecting to the first coil conductor 62a may be disposed at a different planar position from or at the same planar position as a position of the second connection terminal 66a connecting to the second coil conductor 63a. Disposition of the two connection terminals at the same planar position makes a common terminal at that position. Fig. 16 illustrates a case of different disposition. The first substrate 61a and the second substrate 61b are laminated by bonding the first connection terminal 65b to the second connection terminal 66a disposed at the same planar position as the first connection terminal 65b with a gap provided between the two substrates. The level of the second connection terminals 66a are

made higher than the level of the second coil conductors 63a. Number of output systems can be increased by laminating increased number of inductors.

[0029]

A coil for the first inductor 60a is composed of the first coil conductors 62a formed on the first principal surface, the first coil conductors 62b formed on the second principal surface, and first connecting conductors 64a connecting these coil conductors.

A coil of the second inductor 60b is composed of the second coil conductors 63a formed on the first principal surface, the second coil conductors 63b formed on the second principal surface, and second connecting conductors 64b connecting these coil conductors.

Fig. 17 is a cross sectional view of a lamination of the first inductor and the second inductor shown in Fig.16. Fig. 17(a) is a cross sectional view along the line X-X in Fig. 16(a) and Fig. 16(b), and Fig. 17(b) is a cross sectional view along the line Y-Y in Fig. 16(a) and Fig. 16(b).

[0030]

These drawings also indicate the first connection terminals 65a, 65b and the second connection terminals 66a, 66b for electrical connection as well as the coil patterns of the inductors.

Of the first coil conductors 62a and 62b formed on the first substrate 61a, the first coil conductors 62b formed on the second principal surface have straight line shape as shown in Fig. 16 and

electrically connect through the connecting conductors 64a to the first coil conductors 62a formed on the first principal surface. The first coil conductors 62a on the first principal surface are formed slightly oblique with respect to the first coil conductors 62b on the second principal surface for connecting to respective adjacent first conductors 62b on the second principal surface. A coil as a whole composed of the first coil conductors 62a, 62b and the connecting conductors 64a has a solenoid shape.

[0031]

The second conductors 63a and 63b on the second substrate 61b are similar to the first coil conductors 62a and 62b on the first substrate 61a. The second coil conductors 63a on the first principal surface electrically connects through the connecting conductors 64b to the second coil conductors 63b on the second principal surface.

Each of the first inductor 60a and the second inductor 60b has a magnetic core of the magnetic substrate. The inductors are arranged with a gap between them so that the first substrate 61a and the second substrate 61b do not contact with each other. The gap magnetically isolates the two inductors 60a and 60b from each other. The magnetic insulation here means that any induced voltage is not mutually generated when electric current flows in the inductor 60a or the inductor 60b in operation as a power supply. (That means the mutual inductance is low enough not to affect operation of the power supply.)

[0032]

The inductor 60a and the inductor 60b construct a laminated structure by bonding the first connection terminals 65b on the first substrate 61a and the second connection terminals 66a on the second substrate 61b. The bonding between the first connection terminals 65b and the second connection terminals 66a can be conducted by a method selected from soldering, ultrasonic bonding, conductive paste, thermocompression bonding, and anisotropic conductive material. Material for the joining surfaces of the first and the second connection terminals are selected suitably to the method employed. For example, the surface materials suited to soldering are copper, tin, and solder; the material suited to ultrasonic bonding and thermocompression bonding is gold.

Electromagnetic characteristics are not affected if the space between the first substrate 61a and the second substrate 61b is left vacant without any filler material. However, it is preferable to fill the space with a resin and join the two substrates considering mechanical strength and long term reliability.

[Example 4]

Fig. 18 is a cross sectional view of essential parts of fourth example of embodiment of a micro power converter with plural outputs according to the present invention. Fig 18 shows a micro power converter with plural outputs produced by using the inductors 60a and 60b shown in Fig. 16.

[0033]

Two types of main components, inductors and power supply IC of a power converter, are miniaturized by disposing a semiconductor substrate 72 (power supply integrated circuit) over the first principal surface of the first substrate 61a. Since the power supply IC is designed to have two output systems, the power converter is provided with two output systems by provision of two inductors, the first inductor 60a and the second inductor 60b. In the structure of Fig. 18, stud bumps 71 formed on the semiconductor substrate 72 are ultrasonically bonded to the first connection terminals 65a formed on the first substrate 61a for joining the semiconductor substrate 72 including the power supply IC to the inductors 60a and 60b. Underfil 73 can be used for sealing, as necessary.

[0034]

Referring to Fig. 16, electric current flows from the power supply IC on the semiconductor substrate 71 to the first and second inductors 60a and 60b through the stud bumps 71 that are in contact with the first connector terminals 65a of the first inductor 60a: the first connector terminal 65a at A of the first inductor 60a, the first connector terminal 65a at B of the first inductor 60a, the first connector terminal 65a at E of the first inductor 60a connecting to the second connector terminal 66a at C of the second inductor 61b, and the first connector terminal 65a at F of the first inductor 60a connecting to the second connector terminal 66a at D of the second

inductor 61b. The other stud bumps 71 formed on the semiconductor substrate 7 are in contact with other first connector terminals 65a of the first inductor 60a.

A capacitor(s) is omitted in Fig. 18. Although discrete capacitor may be provided, a capacitor component of laminated ceramic capacitor array can be disposed under the back surface of the second inductor for further miniaturization of a power converter. Such a capacitor(s) is electrically connected through the second connection terminals 66b formed on the back surface of the second substrate 61b. Each of the coil conductors 62a, 62b, 63a, 63b is covered with a protective film 68 (see Fig. 26) of an insulative resin material for protection, though not shown in the plan view of Fig. 16.

[0035]

Figs. 19 through 29 are cross sectional views showing a method for manufacturing the micro power converter with plural outputs of Fig. 18 in sequence of the manufacturing steps. Each of the figures corresponds to a cross section along the line Y-Y in Fig. 16.

Manufacturing methods for the first inductor 60a and the second inductor 60b are almost same. The two inductors are manufactured separately and joined together. The Figs. 19 through 29 show a manufacturing method for the second inductor 60b.

At first, a ferrite substrate of Ni-Zn having thickness of 525 μm was prepared for a second substrate 61a. A thickness of the magnetic insulative substrate is determined depending on necessary

inductance, coil current, and properties of the magnetic substrate, and is not limited to the value of this example. However, if the magnetic insulative substrate is extremely thin, magnetic saturation tends to occur; if the substrate is too thick, the power converter itself becomes thick. Accordingly, the thickness needs to be determined matching to purpose of the power converter. Though a magnetic insulative substrate of ferrite was used in this example, other any appropriate insulative and magnetic substrate can also be used. A ferrite substrate was used here for ease of shaping to a substrate form.

[0036]

At first, referring to Fig. 19, through holes 92 are formed for connecting the second coil conductors 63a on the first principal surface and the second coil conductors 63b on the second principal surface of the second substrate 61b by the connecting conductors 64b. At the same time, through holes 93 are formed for connecting the second connection terminals 66a on the first principal surface and the second connection terminals 66b on the second principal surface of the second substrate 61b by the connecting conductors 67b. Machining of the through holes 92 and 93 can be conducted by any method among laser beam machining, sand blasting, electric discharge machining, ultrasonic machining, and drilling. A method is to be selected taking machining cost and machining dimensions into consideration. The sand blasting method was employed in this

example since the minimum dimension, which is a diameter of the hole, was a small value of 130 μm and a large number of holes were to be machined. Though the size of the substrate 61b as shown by solid lines in the Fig. 19 is a size for installing only one inductor, actual size of the substrate is larger allowing fabricating a plurality of inductors as shown by the dotted lines in the figure. The substrate is cut in the last step to obtain individual inductors.

[0037]

Then, the connecting conductors 64b and 67b in the through holes, second coil conductors 63a and connection terminals 66a on the first principal surface, and second coil conductors 63b and connection terminals 66b on the second principal surface are formed.

Referring to Fig. 20, a seed layer for plating 94 of a film of copper / titanium is formed by sputtering to give electrical conductivity on whole surface of the substrate. Though the through holes are also given electrical conductivity, electroless plating may further be executed as required. The sputtering method may be replaced by vacuum deposition or CVD (chemical vapor deposition). The seed layer for plating 94 can alternatively formed only by electroless plating. The method is desired to provide sufficient adhesiveness with the substrate. The conductive material can be any appropriate material exhibiting electrical conductivity. Though titanium was used for the adhesive layer, other materials including Cr, W, Nb, and Ta can also be used. The copper works as a seed layer for next step of

electroplating. The copper can also be replaced by nickel or gold. The copper / titanium was selected in this example considering ease of machining in the later steps.

[0038]

Then, photoresist 95 is applied and a resist pattern is formed by photolithography for forming second coil conductors 63a and first connection terminals 66a on the first principal surface and second coil conductors 63b and first connection terminals 66b on the second principal surface as shown in Fig. 21. The pattern was formed with negative type, film type photoresist. The photoresist 95 was 40 μm thick.

Then, copper is deposited in the openings of the resist pattern by electroplating as shown in Fig. 22. At this time, the through holes 91 and 93 are also plated with copper, and the connecting conductors 64b and 67b are also formed. Thus, the second coil conductors 63a on the first principal surface are connected to the second coil conductors 63b on the second principal surface to form a solenoid coil. A pattern of second connection terminals 66a and 66b are also formed at this time. The copper plating layer has a thickness of 35 μm.

[0039]

Then, only the second connection terminals 66a are made thicker for the purpose of avoiding contact between the first coil conductors 62b and the second coil conductors 63a when the first substrate 61a and the second substrate 61b are combined. Photoresist 96 is applied

and a resist pattern is formed by photolithography as shown in Fig. 23. Referring to Fig. 24, a metallic film 66d is additionally formed by electroplating on the metallic film 66c formed previously to raise the second connection terminal 66a. The second principal plane (back surface) in which the raise is unnecessary is covered with a plain resist film 96 without any pattern. The raising step of Figs. 23 and 24 is unnecessary for the first inductor 60a though not forbidden. Amount of the raise that is the thickness of the metallic film 66d was 5 μm. By virtue of the raise, the level of the surface of the second connection conductors 66a are made higher than the level of the surface of the coil conductors 63a, thereby achieving magnetic isolation between the first inductor 60a and the second inductor 60b.

[0040]

After the electroplating, useless resist and conductive layers are removed to obtain second coil conductors 63a, 63b and second connection terminals 66a, 66b as shown in Fig. 25.

The second coil conductors 63a and 63b are covered with insulator film 68 as shown in Fig. 26. A film type insulator material was used in this example. The insulator film works as a protective film and is not necessarily formed. However, provision is desirable considering long term reliability. The insulator film is not limited to forming with a film type material, and liquid insulator material can also be used to form a pattern by screen printing followed by thermal curing.

[0041]

The second coil conductors 63a, 63b and the second connection terminals 66a, 66b may be plated with nickel, gold to form a surface treatment layer, as necessary. In the process as shown in Fig. 22 in this example, nickel and gold were electroplated subsequently to the electroplating of copper. The raising of the second connection terminals 66a in Fig. 24 was conducted by electroplating of gold. The surface treatment layer may be formed by electroless plating after the step of Fig. 25. Or the electroless plating may be conducted after the step of Fig. 26. The surface treatment layer of metallic protective conductor is helpful for holding stable condition in a later step of connecting the IC.

[0042]

The first inductor 60a is formed by the process similar to the process for forming the second inductor 60b described above. The first inductor 60a is fixed to the second inductor 60b with the connection terminals 65b and the connection terminals 66a. Since the connection terminals 66a are raised, a gap is generated between the first substrate 61a and the second substrate 61b to achieve magnetic isolation of the two substrates. Contact of the first coil conductor 62b and the second coil conductors 63a is also avoided.

Bonding of the two substrates was performed by thermocompression bonding. The bonding may also be executed by soldering, conductive paste bonding, ultrasonic bonding, or a method

using an anisotropic conductive material in addition to the thermocompression bonding. Selection of the method is made considering temperatures and other conditions in the later steps. The space between the two substrates may be filled with a resin material as required. The resin can be applied beforehand or injected afterward. In the case the two substrates are bonded together, preliminary application is preferable.

[0043]

A semiconductor substrate 72 installing a power supply IC 22 is connected to the first connection terminals 65a formed on the first substrate 61a as shown in Fig. 28. In this example, stud bumps 71 are formed on the semiconductor substrate 72 installing a power supply IC, and the stud bumps 71 are bonded to the first connection terminals 65a by ultrasonic bonding. The semiconductor substrate 72 is fastened to the first inductor 60a with an underfil 73 as shown in Fig. 29. Cutting along cut line 81, a micro converter device comprising a semiconductor substrate and plural inductors is completed. The stud bump and ultrasonic bonding were employed in this example for fastening the semiconductor substrate and the inductors. A method of the fastening is, however, not limited to this measure. Soldering or a method using a conductive adhesive can also be employed without a problem. Nevertheless, resistance of connection parts is favorably as small as possible. The cutting may be executed along cut line 82 to prevent the connection terminals 65a,

65b, 66a, 66b and the connecting conductors 67a, 67b from exposing to the side face.

[0044]

The semiconductor substrate 72 was fastened to the first inductor 60a with the underfil 73 in this example. The fastening, however, can be performed using any appropriate material, for example, a sealant of epoxy resin. The fastening material fastens each of the components and is preferably provided to obtain long term reliability against adverse effects of such as moisture, though does not affect initial performance of the power converter.

By employing the above-described processes, a power converter packaging parts including a power supply IC and inductors, except for a capacitor, can be minimized. The power converter having two output systems occupies smaller packaging area than two micro power converters having one output system each.

[0045]

Specifically, a conventional micro power converter with one output system has a size of 3.5 mm wide and 3.5 mm long. To obtain two outputs by that type of converter, at least an area of 3.5 mm wide and 7.0 mm long is necessary. Total thickness of the inductors is about 0.6 mm and a thickness of the semiconductor substrate 72 installing a power supply IC is about 0.3 mm, summing up to an overall thickness of about 0.9 mm. In the actual packaging area, at least a length of 7.2 mm is necessary considering actual possible

packaging construction.

In the structure of the invention, a packaging area is 3.5 mm wide and 3.5 mm long. A thickness is about 1.5 mm since a thickness of one inductor is added. Thus, a packaging area is reduced to a half. A total volume of a power converter is reduced to about 80 % of the conventional one, and packaging cost decreases to a half.

[0046]

Further minimization of a micro power converter can be achieved by bonding a laminated ceramic capacitor(s) to the connection terminals of the inductor on the reverse face from the face that packages the IC. Planar size and thickness of the first and second inductors 60a, 60b formed on the first and second substrates were not changed in the example described so far.

Since in an actual packaging structure applying a micro power converter, a size in the thickness direction is often restricted, a thickness needs to be minimized. In this example, a ferrite substrate 0.3 mm thick was used to reduce a total thickness.

In another specific example, a size of each of the first and second inductors 60a, 60b is 4 mm wide and 4 mm long. Number of turns is increased from 11 turns in the previous example to 14 turns in this example corresponding to the increase of the size. The inductance value of 2.0 μH of the former example is preserved in the latter example by increasing size and number of turns corresponding to decrease in thickness of the inductor. A thickness of each inductor is

about 0.4 mm after formation of the coil. A micro power converter manufactured using this inductor has a planar size of 4 mm x 4 mm and a small thickness of 1.1 mm including a semiconductor substrate 72. The packaging are is 57 % and the volume is 80 % of the conventional one. Optimization is performed by designing the planar size and thickness within permissible limits.

[0047]

Though the shapes of the coil conductors described thus far are solenoids, a toroidal shape as shown in Fig. 30 may also be taken. A toroidal coil has a closed magnetic pass structure in which a magnetic flux generated by the coil passes within a magnetic substrate. A micro power converter with plural outputs can be produced by laminating inductors having the toroidal coils lake in Example 4.

A spiral shape as shown in Fig. 31 is an open magnetic pass structure in which the magnetic flux leaks out. Consequently, magnetic isolation between the inductors must be considered. If the inductors are laminated with a remote distance, a micro power converter with plural outputs can be obtained like in Example 4.

[0048]

[Effect of the invention]

As described thus far, a plurality of inductors are integrated in a magnetic insulative substrate with a magnetic isolation layer between the inductors, or a plurality of magnetic substrates comprising an inductor formed on each of the substrates are

laminated with a gap between the substrates. Either structure forms a micro power converter with plural outputs. A plurality of micro power converters required corresponding to output systems in the prior art can be aggregated to one device in an invented micro power converter. Such a converter of the invention reduces a packaging area and packaging costs.

[Brief description of drawings]

Fig. 1 is a plan view of an essential part of the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 2(a) is a cross sectional view along the line X-X in Fig. 1 of an essential part of an inductor shown in Fig. 1.

Fig. 2(b) is a cross sectional view along the line Y-Y in Fig. 1 of an essential part of inductors shown in Fig. 1.

Fig. 3 is a cross sectional view of an essential part of the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 4 is a partial sectional view illustrating a step of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 5 is a partial sectional view illustrating a step, following the step of Fig. 4, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present

invention.

Fig. 6 is a partial sectional view illustrating a step, following the step of Fig. 5, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 7 is a partial sectional view illustrating a step, following the step of Fig. 6, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 8 is a partial sectional view illustrating a step, following the step of Fig. 7, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 9 is a partial sectional view illustrating a step, following the step of Fig. 8, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 10 is a partial sectional view illustrating a step, following the step of Fig. 9, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 11 is a partial sectional view illustrating a step, following the step of Fig. 10, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the

present invention.

Fig. 12 is a partial sectional view illustrating a step, following the step of Fig. 11, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 13 is a partial sectional view illustrating a step, following the step of Fig. 12, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 14(a) is a partial sectional view illustrating a step for forming a ferrite substrate in the second example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 14(b) is a partial sectional view illustrating a step, following the step of Fig. 14(a), for forming the ferrite substrate in the second example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 14(c) is a partial sectional view illustrating a step, following the step of Fig. 14(b), for forming the ferrite substrate in the second example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 15 is a partial sectional view illustrating four inductors integrated on a magnetic insulative substrate.

Fig. 16(a) is a plan view of an essential part of a first inductor in

the third example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 16(b) is a plan view of an essential part of a second inductor in the third example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 17(a) is a cross sectional view, along the lines X-X in Figs. 16(a) and 16(b), of a laminated structure of the first inductor and the second inductor in Figs. 16(a) and 16(b).

Fig. 17(b) is a cross sectional view, along the lines Y-Y in Figs. 16(a) and 16(b), of a laminated structure of the first inductor and the second inductor in Figs. 16(a) and 16(b).

Fig. 18 is a cross sectional view of an essential part of fourth example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 19 is a sectional view illustrating a step of manufacturing the micro power converter with plural outputs of Fig. 18.

Fig. 20 is a sectional view illustrating a step, following the step of Fig. 19, of manufacturing the micro power converter with plural outputs of Fig. 18.

Fig. 21 is a sectional view illustrating a step, following the step of Fig. 20, of manufacturing the micro power converter with plural outputs of Fig. 18.

Fig. 22 is a sectional view illustrating a step, following the step of Fig. 21, of manufacturing the micro power converter with plural

outputs of Fig. 18.

Fig. 23 is a sectional view illustrating a step, following the step of Fig. 22, of manufacturing the micro power converter with plural outputs of Fig. 18.

Fig. 24 is a sectional view illustrating a step, following the step of Fig. 23, of manufacturing the micro power converter with plural outputs of Fig. 18.

Fig. 25 is a sectional view illustrating a step, following the step of Fig. 24, of manufacturing the micro power converter with plural outputs of Fig. 18.

Fig. 26 is a sectional view illustrating a step, following the step of Fig. 25, of manufacturing the micro power converter with plural outputs of Fig. 18.

Fig. 27 is a sectional view illustrating a step, following the step of Fig. 26, of manufacturing the micro power converter with plural outputs of Fig. 18.

Fig. 28 is a sectional view illustrating a step, following the step of Fig. 27, of manufacturing the micro power converter with plural outputs of Fig. 18.

Fig. 29 is a sectional view illustrating a step, following the step of Fig. 28, of manufacturing the micro power converter with plural outputs of Fig. 18.

Fig. 30 shows a coil of a toroidal shape.

Fig. 31 shows a coil of a spiral shape.

Fig. 32 shows a DC-DC converter circuit.

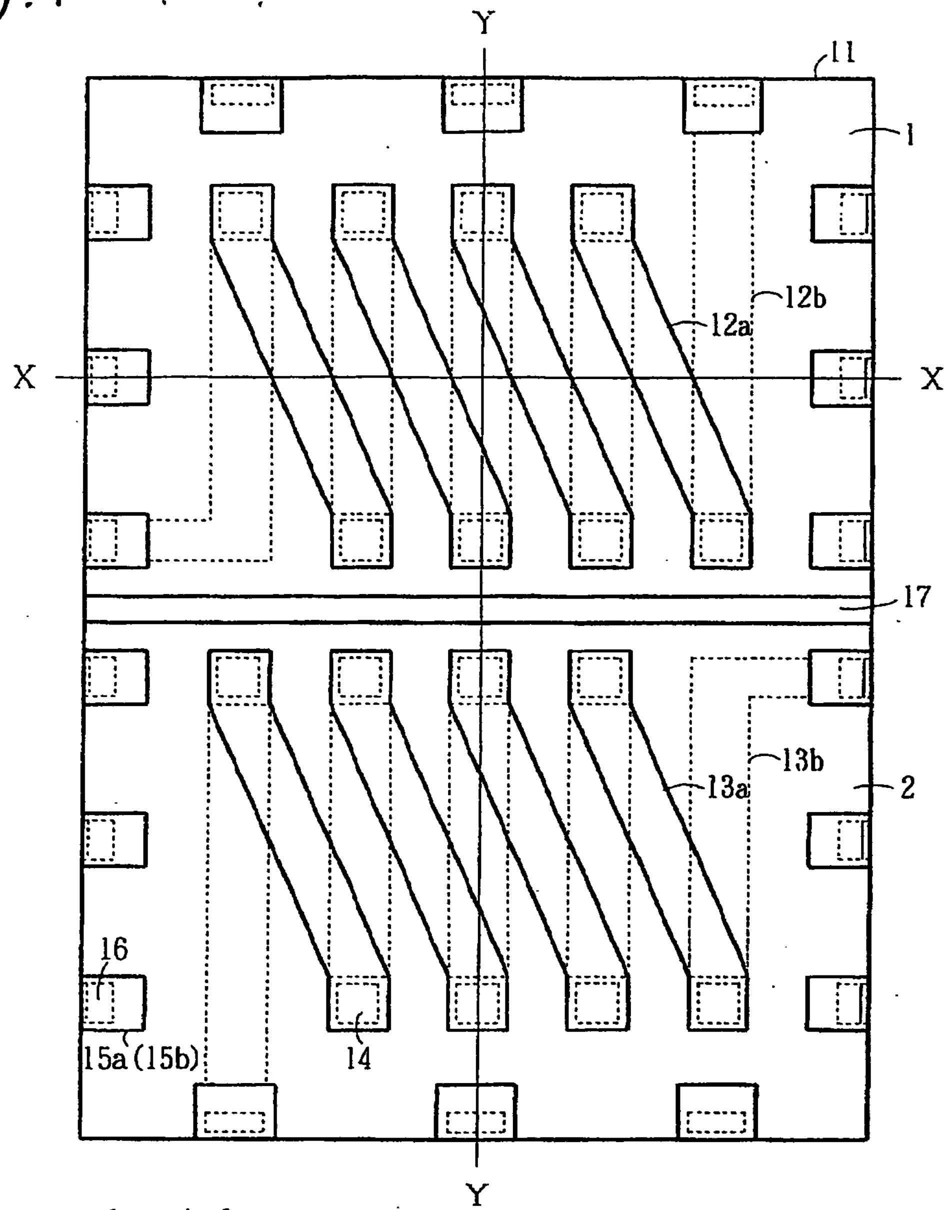
[Description of symbols]

1, 2	inductor
10	tape
11	magnetic insulative substrate / a ferrite substrate
12a, 13a	coil conductor (on first principal surface)
12b, 13b	coil conductor (on second principal surface)
14, 16	connecting conductor
15a	connection terminal (on first principal surface)
15b	connection terminal (on second principal surface)
17	magnetically isolating layer
18	protective film (insulative film)
21	stud bump
22	semiconductor substrate
23	underfil
42, 43, 53, 54	through hole
44	seed layer for plating
45	photoresist
51	ferrite green sheet
55	ceramic paste
60a	first inductor
60b	second inductor
61a	first substrate

61b	second substrate
62a	first coil conductor (on first principal surface of first substrate)
62b	first coil conductor (on second principal surface of first substrate)
63a	second coil conductor (on first principal surface of second substrate)
63b	second coil conductor (on second principal surface of second substrate)
64a, 64b	connecting conductor of first substrate
65a	first connection terminal (on first principal surface of first substrate)
65b	first connection terminal (on second principal surface of first substrate)
66a	second connection terminal (on first principal surface of second substrate)
66b	second connection terminal (on second principal surface of second substrate)
67a, 67b	connecting conductor (of second substrate)
71	stud bump
72	semiconductor substrate
73	underfil
92, 93	through hole
94	seed layer for plating

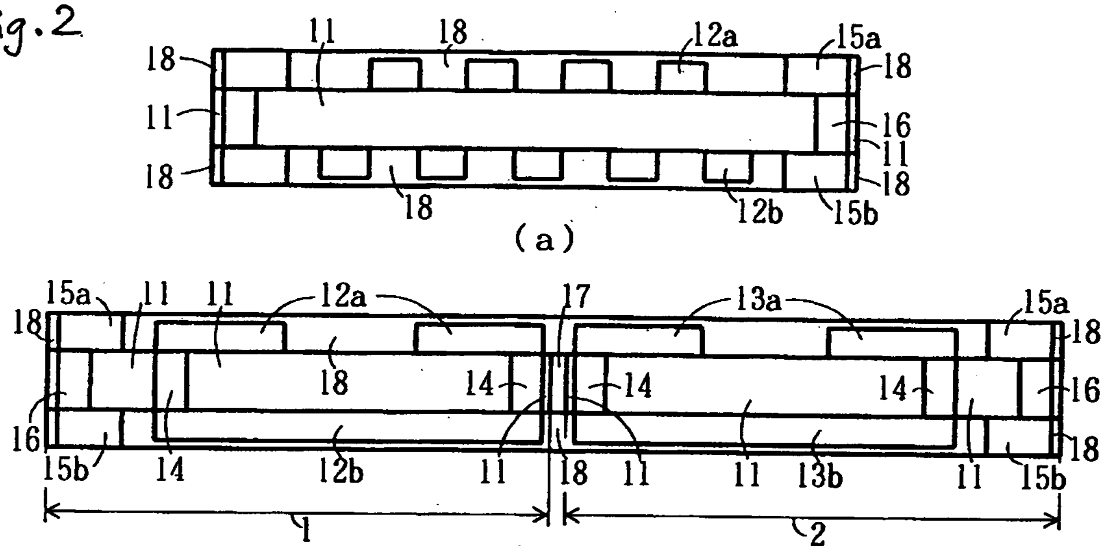
95, 96	photoresist
66c, 66d	metallic film
81, 82	cut line

Fig: 1



1 inductor
2 inductor
11 magnetic insulative substrate (a ferrite substrate)
12a coil conductor on first principal surface
12b coil conductor on second principal surface
13a coil conductor on first principal surface
13b coil conductor on second principal surface
14 connecting conductor
15a connection terminal on first principal surface
15b connection terminal on second principal surface
16 connecting conductor
17 magnetically isolating layer

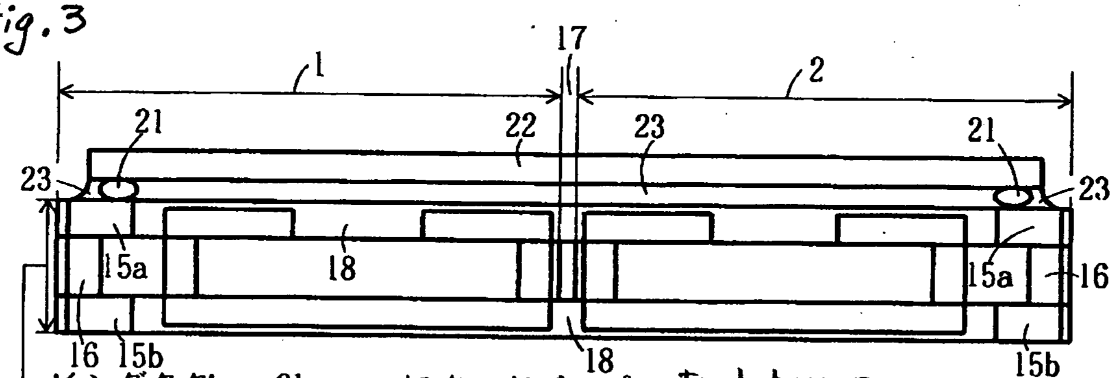
~~【図2】~~
Fig.2



(a)

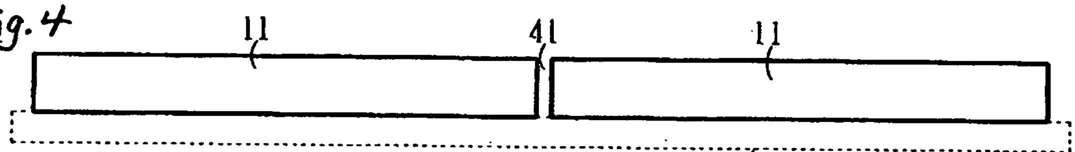
(b)

~~【図3】~~
Fig.3



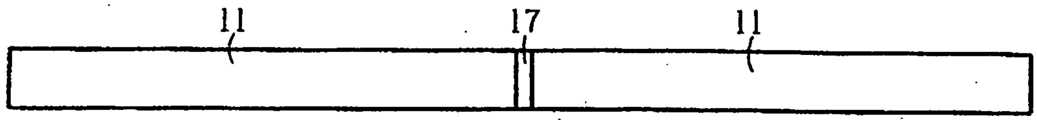
~~インダクタ~~ inductor
21・・・~~スタッドバンプ~~→ stud bump
22・・・~~半導体基板~~→ semiconductor substrate
23・・・~~アンダーフィル~~→ underfil

~~【図4】~~
Fig.4



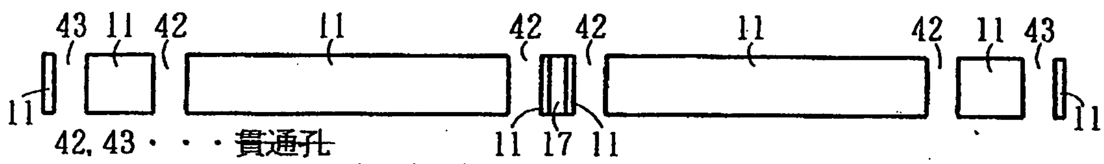
10・・・~~テープ~~ tape 41・・・~~切り代~~ cut gap

~~【図5】~~
Fig. 5



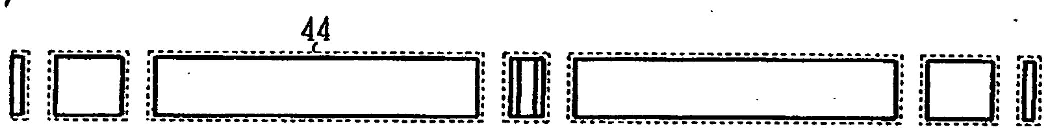
17・・・~~磁気分離層~~ magnetically isolating layer

~~【図6】~~
Fig. 6



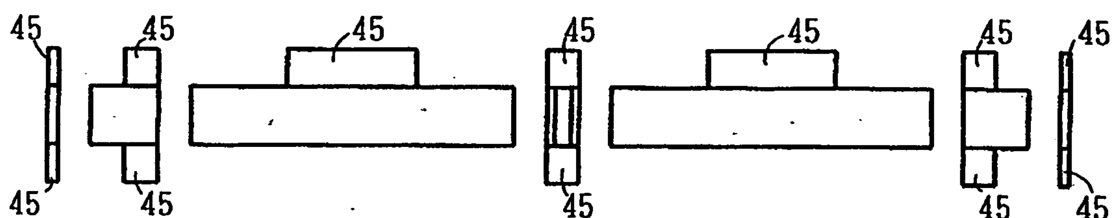
42, 43・・・~~貫通孔~~
through hole

~~【図7】~~
Fig. 7



44・・・~~めっきシード層~~
seed layer for plating

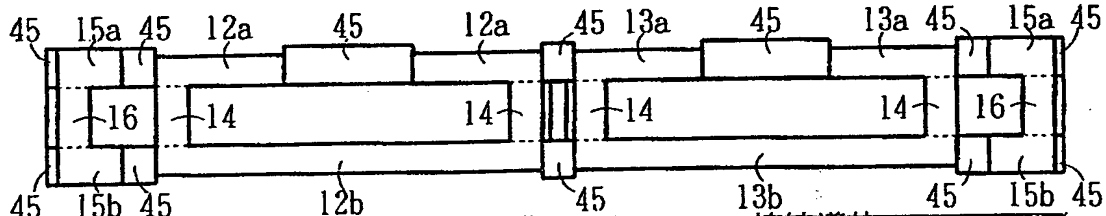
~~【図8】~~
Fig. 8



45・・・~~フォトレジスト~~
photoresist

~~【図9】~~

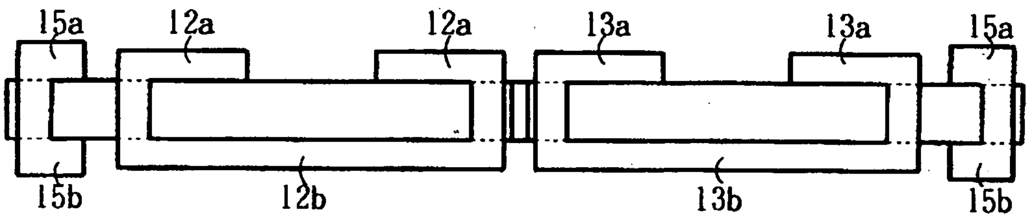
Fig. 9



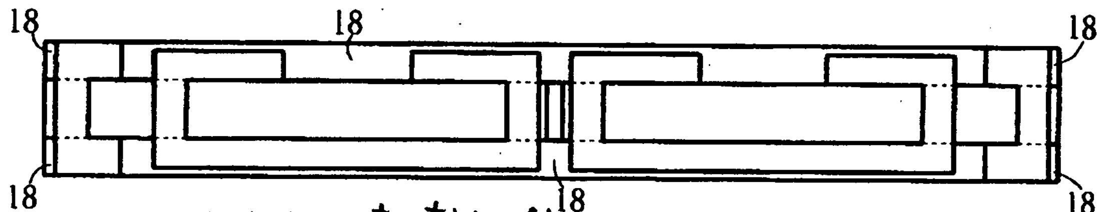
~~12a・・・コイル導体（第１主面）　14・・・接続導体~~
~~12b・・・コイル導体（第２主面）　15a・・・接続端子（第１主面）~~
~~13a・・・コイル導体（第１主面）　15b・・・接続端子（第２主面）~~
~~13b・・・コイル導体（第２主面）　16・・・接続導体~~

12a	coil conductor on first principal surface
12b	coil conductor on second principal surface
13a	coil conductor on first principal surface
13b	coil conductor on second principal surface
14	connecting conductor
15a	connection terminal on first principal surface
15b	connection terminal on second principal surface
16	connecting conductor

~~【図10】~~ Fig.10

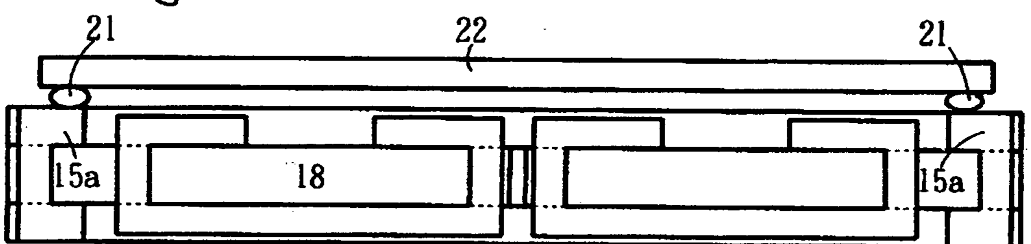


~~【図11】~~ Fig.11



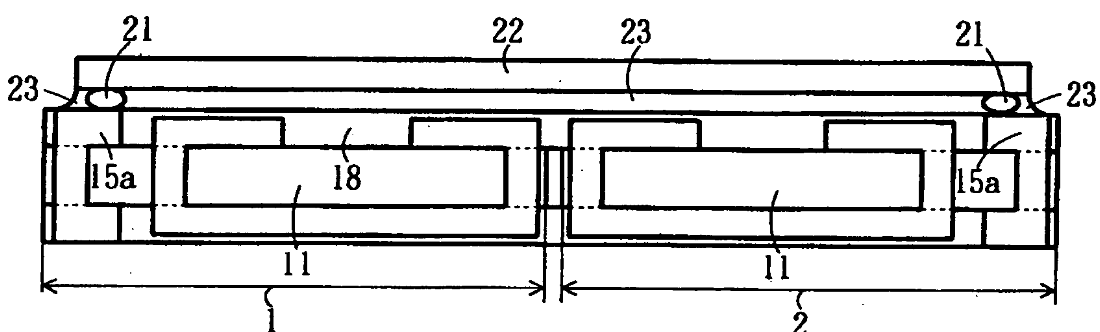
18・・・~~保護膜~~ protective film

~~【図12】~~ Fig.12



21・・・~~スタッドバンプ~~ stud bump 22・・・~~半導体基板~~ semiconductor substrate

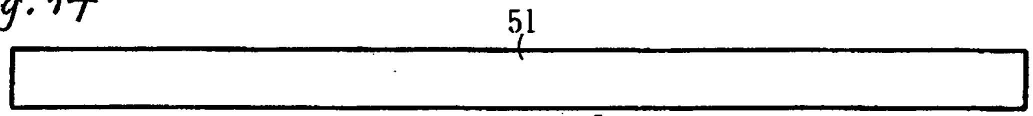
~~【図13】~~ Fig.13



23・・・~~アンダーフィル~~ underfil

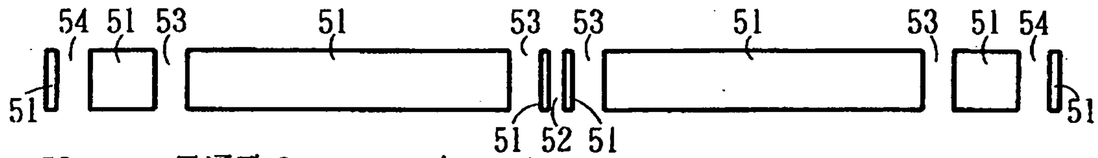
~~【図１４】~~

Fig. 14



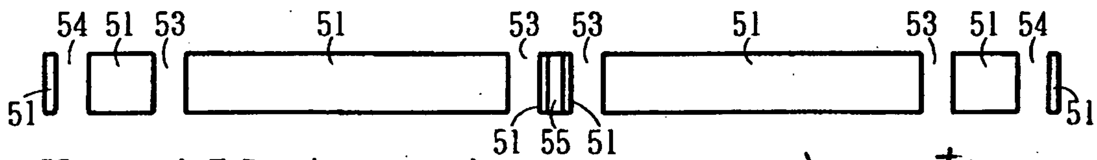
51・・・~~フェライトグリーンシート~~ → ferrite green sheet

(a)



53・・・~~貫通孔~~
54・・・~~貫通孔~~ } through hole

(b)

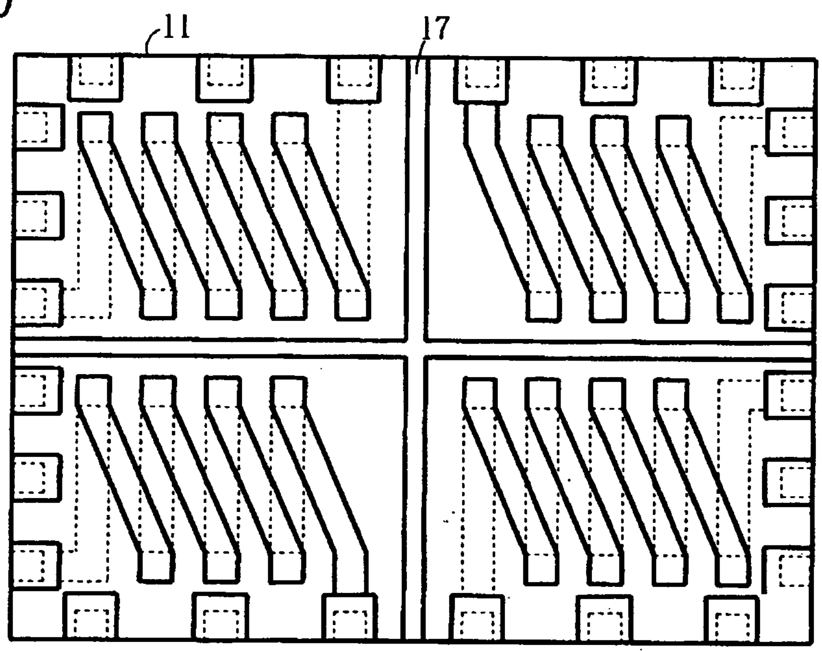


55・・・~~セラミックスペースト~~ → ceramic paste

(c)

~~【図１５】~~

Fig. 15



~~【図16】~~

Fig. 16
(a)

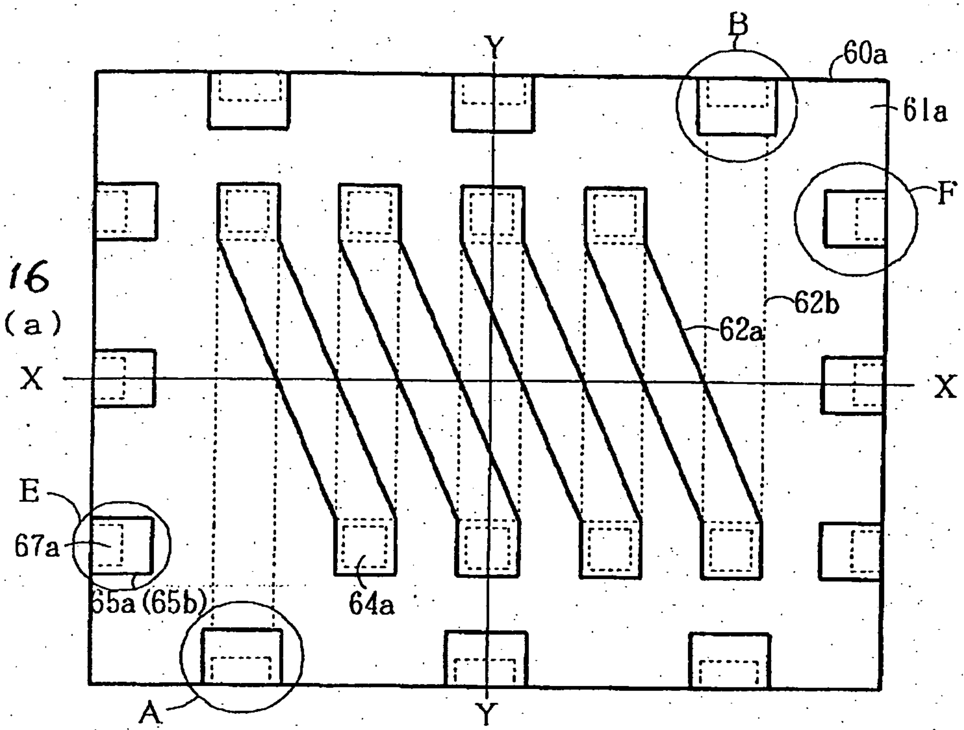
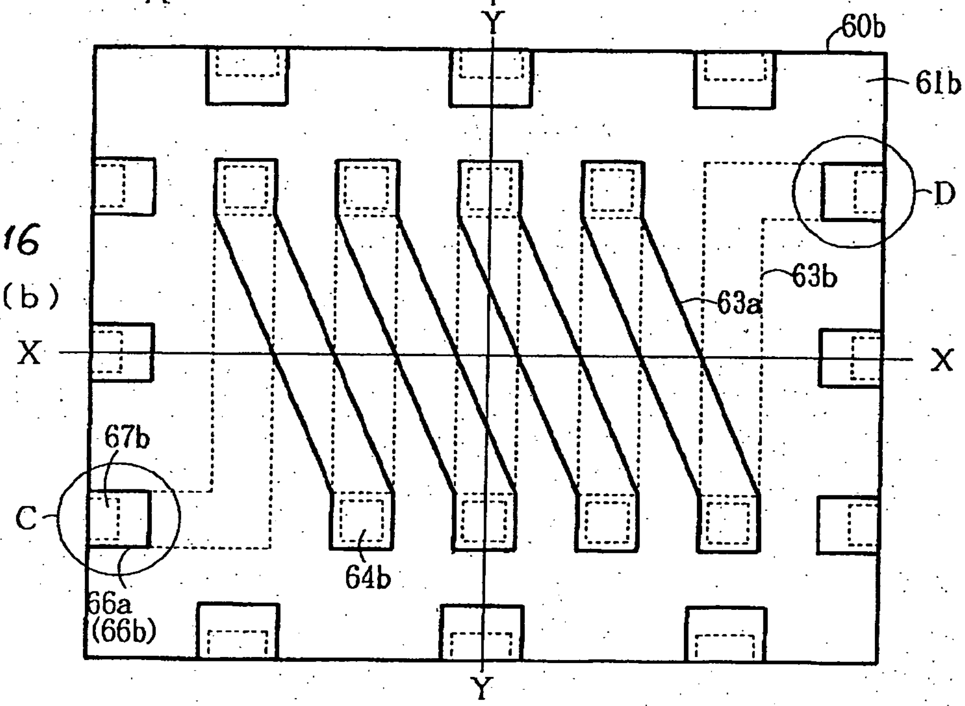
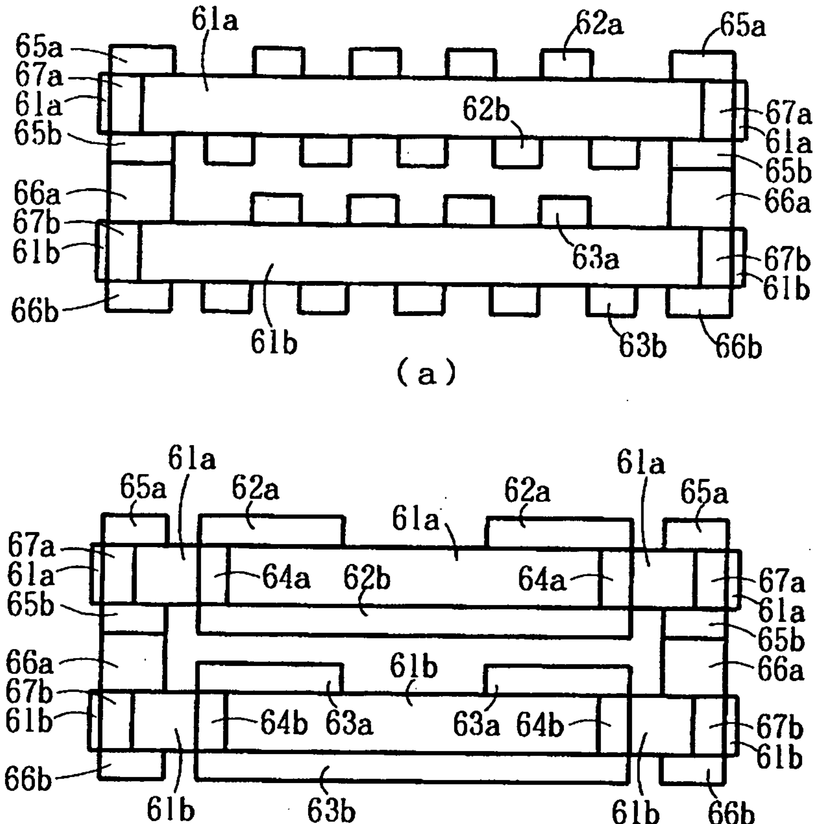


Fig. 16
(b)



60a	first inductor	64a, 64b	connecting conductor
60b	second inductor	65a, 65b	first connection terminal
61a	first substrate	66a, 66b	second connection terminal
61b	second substrate	67a, 67b	connecting conductor
62a, 62b	first coil conductor		
63a, 63b	second coil conductor		

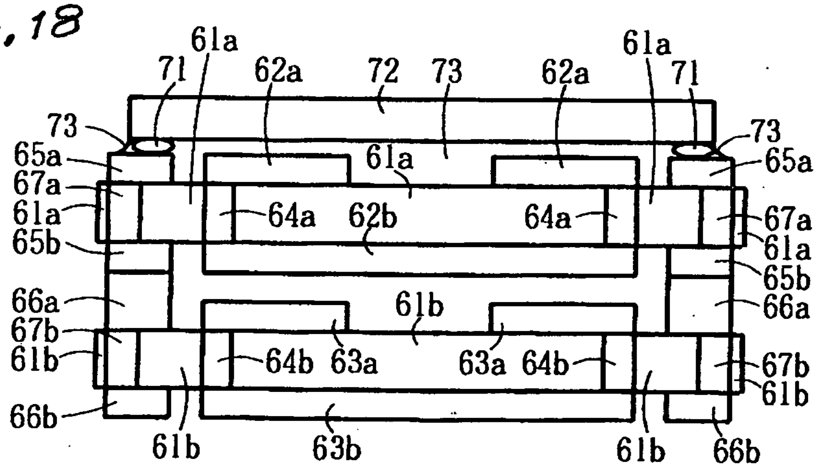
~~【図17】~~
Fig. 17



(a)

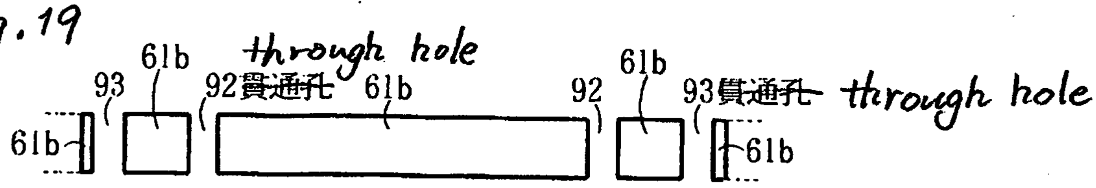
(b)

~~【図18】~~
Fig. 18

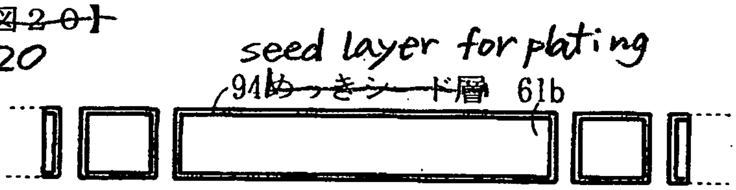


71 ・・・ ~~スタッドバンプ~~ → stud bump
72 ・・・ ~~半導体基板~~ → semiconductor substrate
73 ・・・ ~~アンダーフィル~~ → underfil

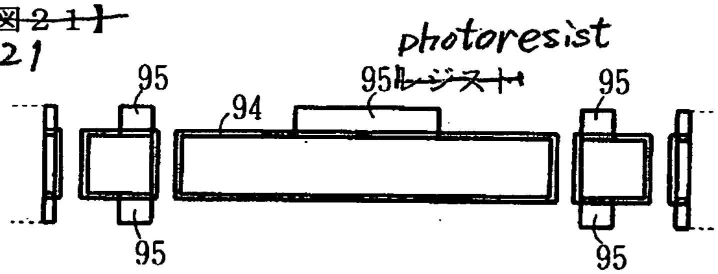
~~【図19】~~
Fig.19



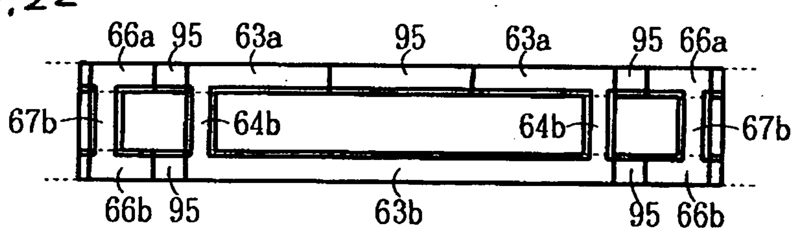
~~【図20】~~
Fig.20



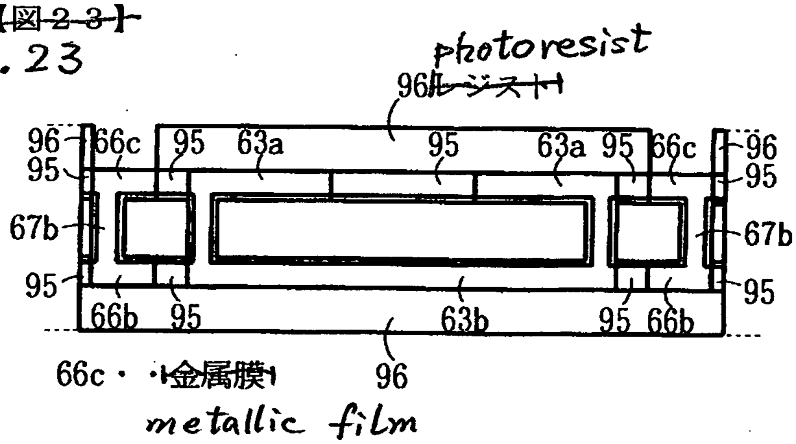
~~【図21】~~
Fig.21



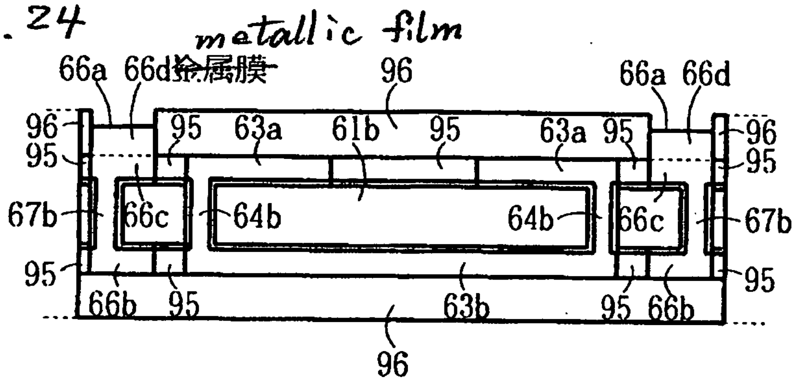
~~【図22】~~
Fig.22



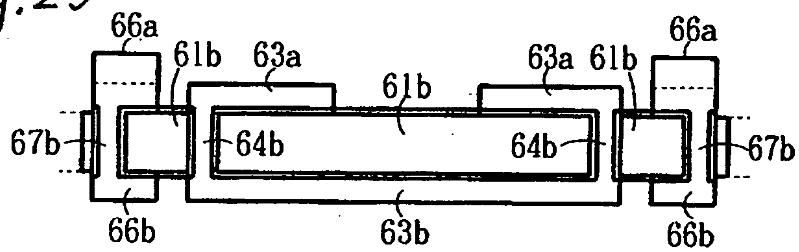
~~【図23】~~
Fig.23



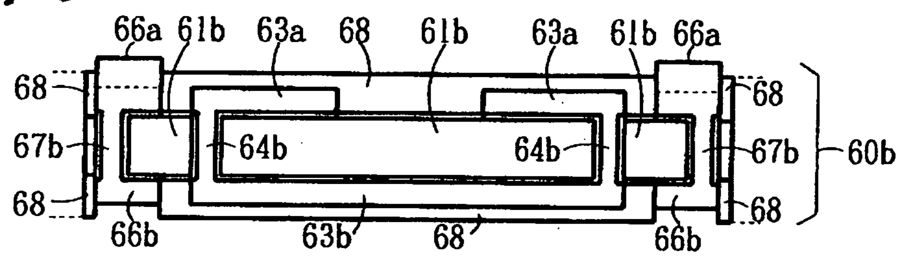
~~【図24】~~
Fig. 24



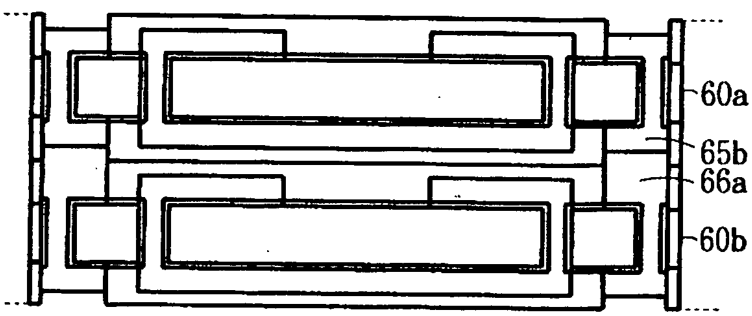
~~【図25】~~
Fig. 25



~~【図26】~~
Fig. 26

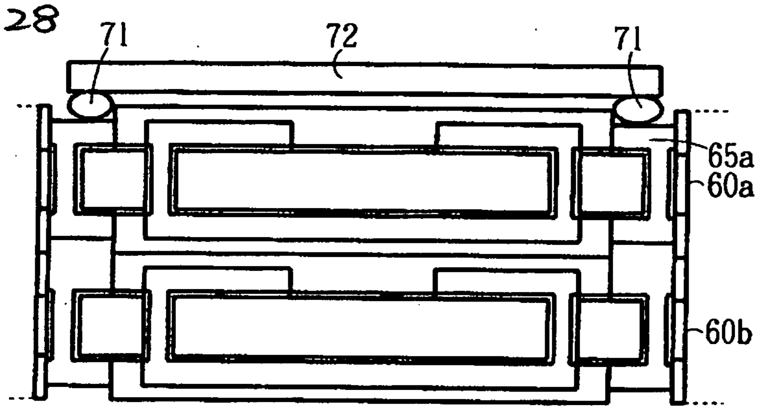


~~【図27】~~
Fig. 27



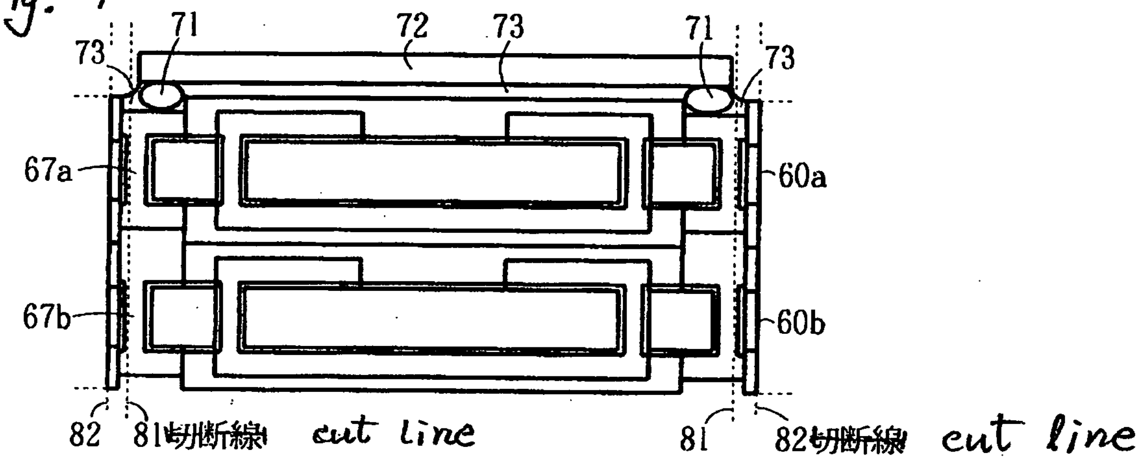
~~【図28】~~

Fig. 28



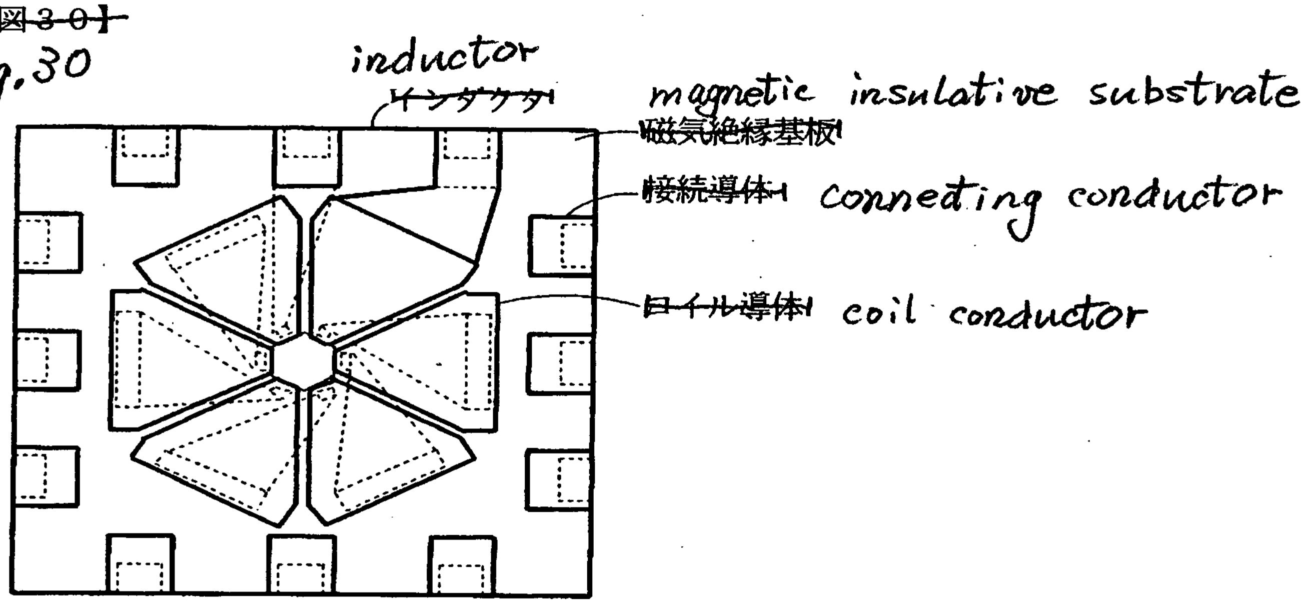
~~【図29】~~

Fig. 29

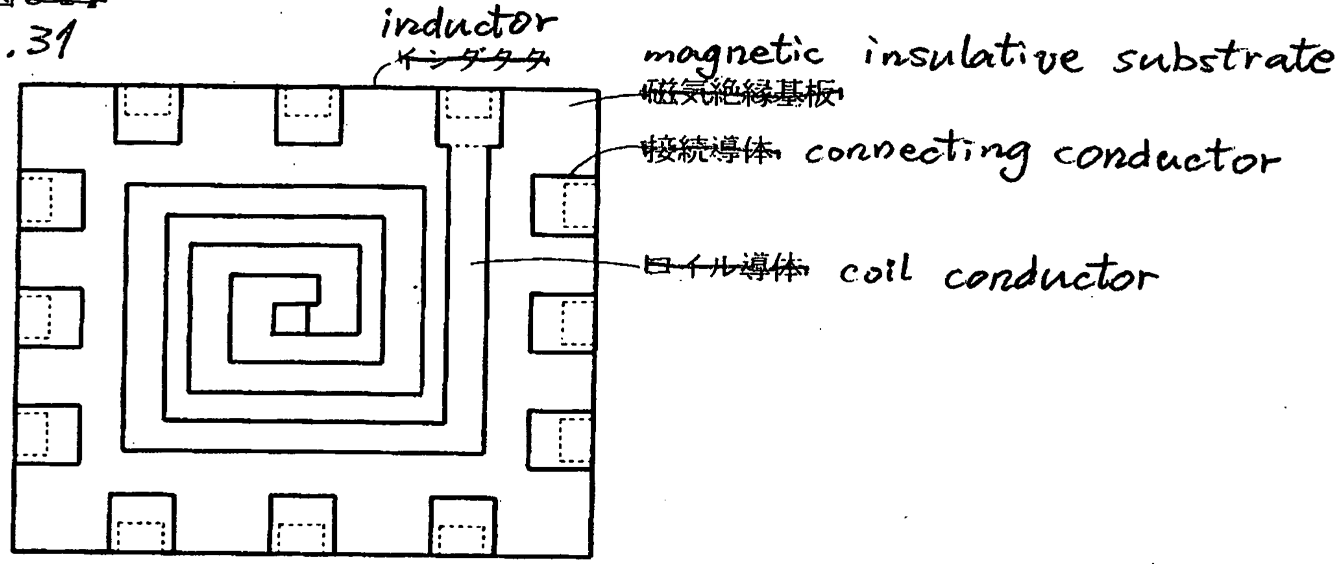


~~【図30】~~

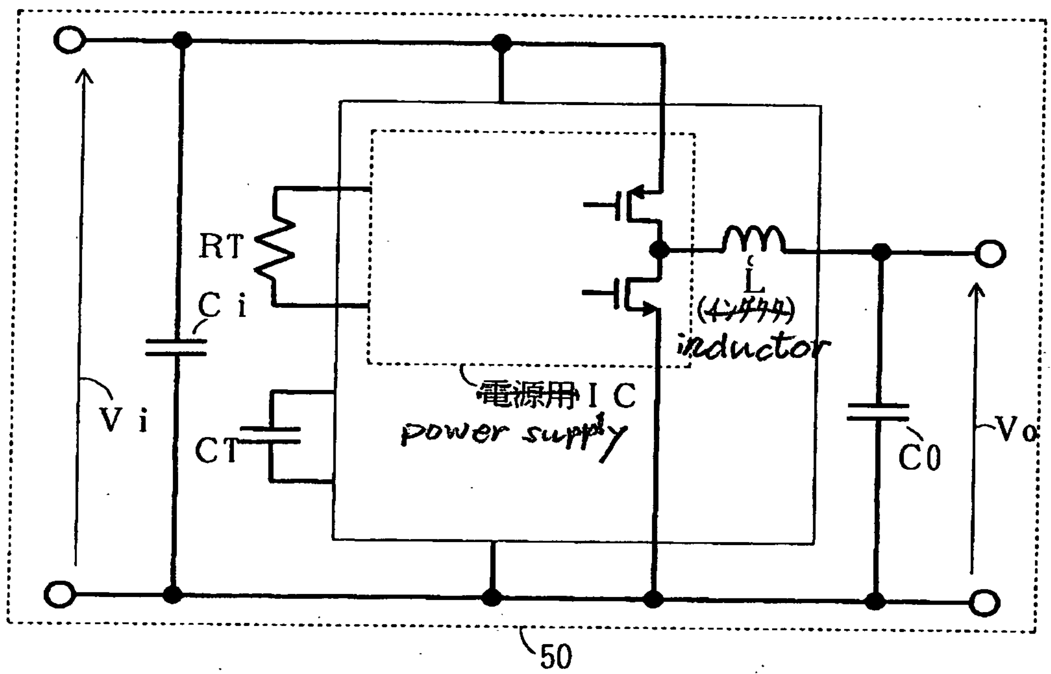
Fig. 30



~~【図31】~~
Fig. 31



~~【図32】~~
Fig. 32



[Document Type] Abstract

[Abstract]

[Problem] An object of the present invention is to provide a micro power converter with plural outputs that outputs plural voltage outputs, is small and thin, occupies small packing area, and has plural output systems.

[Means to solve the problem] A micro power converter with plural outputs according to the present invention comprises two inductors 1, 2 each having a solenoid coil. The coils are composed of coil conductors 12a, 13a formed on a first principal surface of a magnetic insulative substrate 11, coil conductors 12b, 13b having a planar form of a straight line formed on second principal surface of the substrate, and connecting conductors 14 in through holes, the connecting conductors electrically connecting the coil conductors on the first principal surface to the coil conductors on the second principal surface. The two inductors 1, 2 are magnetically isolated from each other by a magnetically isolating layer 17. A micro power converter having plural outputs is obtained by provision of the plural inductors.

[Selected drawing] Figure 1